Noise Diode Evaluation

K. B. Wallace
Communications Elements Research Section

Noise diodes are installed in all R&D microwave receiver systems to check broadband receiver performance required for radiometric applications, such as radio astronomy and atmospheric studies. An application to which noise sources are particularly suited is the noise-adding radiometer; another application being studied is automated system performance evaluation. In this article, noise diodes similar to those in use at Deep Space Stations 13 and 14 are evaluated for variations in noise output due to temperature.

I. Introduction

Noise diodes are installed in all R&D microwave receiver systems at DSSs 13 and 14. They are used to check broadband receiver performance required for radiometric applications, such as radio astronomy and atmospheric studies. A well-calibrated noise source may be used to measure system temperature, the magnitude of astronomical radio sources, and other parameters for which discrete frequency measurements are not applicable.

An application to which noise sources are particularly suited is the noise-adding radiometer (NAR) (Ref. 1). Another application being studied is automated system performance evaluation.

In all of these, noise diode stability is an important parameter. The purpose of this evaluation is to determine temperature characteristics of a few samples. Further evaluations at S-band and other frequency ranges are in progress.

II. Discussion

Four solid-state noise sources have been tested to determine output variations with respect to temperature. Of these, two are similar to those presently in use at Goldstone. They are manufactured by Microwave Semiconductor Corporation (MSC), designated MC 7025, serial numbers 701 and 703. Except for noise output, the two are alike in other respects.

The third sample was supplied by International Microwave Corporation (IMC), designated NCM-2030-3S, serial number 187. The fourth sample was manufactured by Texas Instruments, Model MIC 93S, serial number 15. This device is a microwave integrated circuit, complete with constant-current bias supply.

The test setup is shown in Fig. 1. An S-band receiver of equivalent input noise temperature of approximately 1000 K is terminated at the input with a liquid-nitrogen-cooled coaxial load of equivalent noise temperature of

85 K at 2295 GHz. The purpose of this load is to eliminate receiver variations due to ambient temperature changes.

The receiver is followed by a noise-adding radiometer developed by the Radio Frequency Techniques (RFT) Group, Section 333. This NAR is similar to those in use at Goldstone (Ref. 1), except that it employs a Hewlett-Packard Calculator, HP 9100A and accessories, for computation and control. The NAR is insensitive to gain changes and other receiver fluctuations.

The test device, enclosed in a thermally isolated chamber, is connected to the receiver input through a 20-dB directional coupler.

Samples 1, 2, and 3 are powered by an external constant-current power supply, range 0 to 10 mA. The sample chamber was operated over a temperature range of 0 to 50°C. The system has the capability to measure variation of noise power of a test device to an accuracy of approximately 0.1%. Absolute accuracy is approximately 1%. No effort was made to improve absolute accuracy, since the purpose of the test was the determination of noise power variations of the samples with temperature. The results of the tests are shown in Figs. 2 and 3, and summarized in Table 1.

The conversion of noise output (excess noise) expressed in kelvin to noise output expressed in dB is given by the expression

$$T_{N\,(\mathrm{dB})} = 10 \log \left(\frac{T_{N\,(\mathrm{deg})}}{290} + 1 \right) \tag{1}$$

This conversion is frequently used since manufacturer's specifications of excess noise are in dB and DSN system parameters are expressed in kelvin. Sample 4 could not be operated over a range of bias current. It was run at constant bias over a temperature range of 0 to 50°C.

III. Conclusion

It may be inferred from the test results that higher-power devices show greater percentage variation. Further testing of other noise sources will be required to verify this. Since the higher-power devices are required in R&D systems, the temperature variation must be reduced by using better noise sources or by temperature control.

Reference

1. Batelaan, P. D., Goldstein, R. M., and Stelzried, C. T., "A Noise-Adding Radiometer for Use in the DSN," in *The Deep Space Network*, Space Programs Summary 37-65, Vol. II, pp. 66–69. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1970.

Table 1. Summary of results

Sample	Noise at receiver at ambient temperature, K	Noise from test device at ambient temperature		Maximum variation at peak		Manufacturer's specification
		K	dB	% /°C	dB/°C	dB/°C
Sample 1 (MSC MC 7025, SN 701)	1760	176,000	27.8	0.06	0.01	0.01
Sample 2 (MSC MC 7025, SN 703)	3280	328,000	30.5	0.30	0.12	0.01
Sample 3 (IMC, NCM-2030-3S)	3160	888,000	34.9	0.50	0.10	—
Sample 4 (MIC 93S)	310	31,000	20.1	0.07	0.003	—

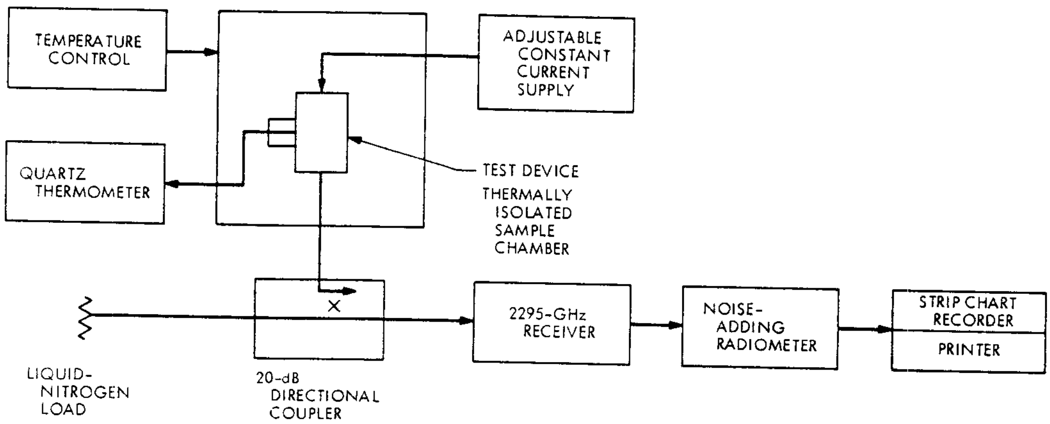

Fig. 1. Test setup

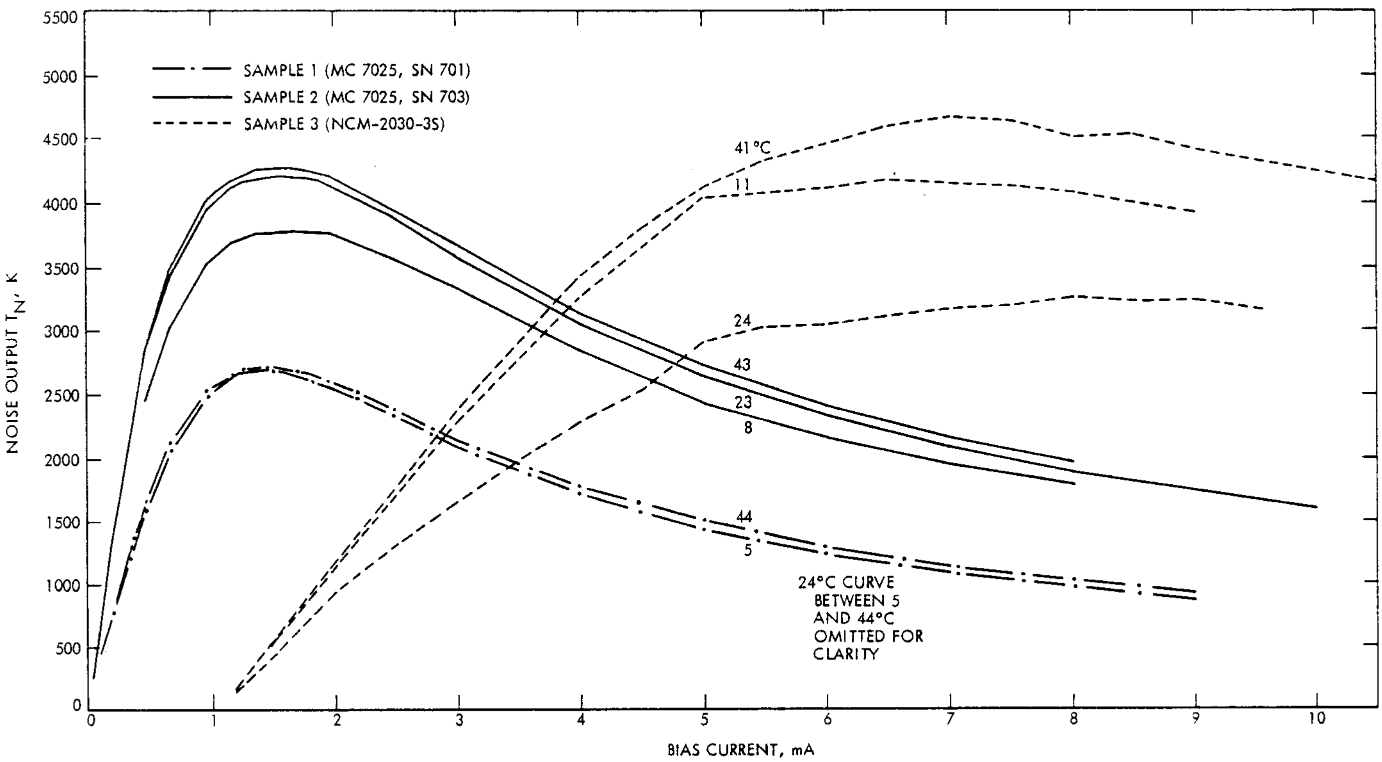

Fig. 2. Noise source output vs bias current and temperature

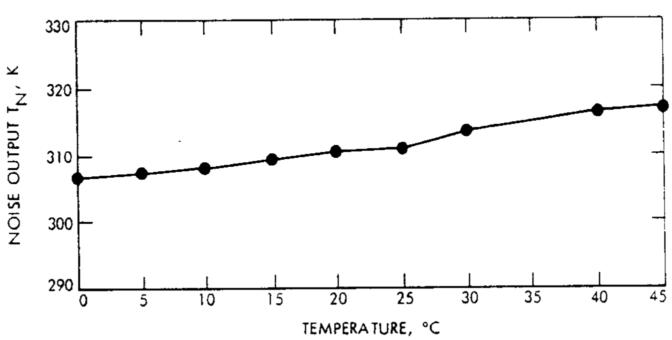

Fig. 3. Test results of sample 4